Atlanta's MARTA:
Running well, still building

May 11, 1981

RAILWAY AGE

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Signaling:
Yesterday, today, and tomorrow

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Inside

LUTHER S. MILLER

A SIGNAL ACCOMPLISHMENT

The history of railroad signaling goes back to the very beginning of railroading, when the oats-vs-coal equation had still not been worked out to the advantage of steam, and horsepower was still just that—horse power. In *This Fascinating Railroad Business*, Robert S. Henry described the first brave attempt at signaling on the horse railroads: "The original idea was that any carter or carrier could run his own vehicles upon the rails upon the payment of toll. It was early found, however, that controlling the movement of vehicles on the road of raised rails had possibilities of conflict and collision which were not present on the ordinary turnpike, whereupon an attempt was made to regulate conflicting claims to the right of way by setting up center posts, halfway between the turnouts provided for meeting, and prescribing that the driver who first passed the center post should have right of way to the turnout." It didn't work. Drivers raced to the center posts to avoid having to back up, and "closely disputed points as to the right of way were sometimes settled by the primitive and direct method of a fist fight."

Signaling, as it's known today, began on the Newcastle & Frenchtown in 1832. Again in the words of Bob Henry: "The signal that the way was clear was a basket covered with white cloth raised to the top of the pole. When the lookout man could see through his spyglass that this round, bell-shaped object was at the top of the pole at the next station ahead, the word passed to the conductor and engineman of the waiting train to go ahead came to be 'high ball.'"

"Highball" remains entrenched in the vocabulary of railroading. But othwerwise the language of signaling has changed as drastically as the science of railroading itself. How drastic the change has been may be seen in some of the illustrations accompanying Associate Editor John Armstrong's look back/look ahead cover story, in this issue (p. 16)—a story timed to coincide with the 100th birthday of one of the oldest railroad supply companies still doing business under its original name, Union Switch & Signal.

POSITIVE WORD FROM ALASKA ON PTC

A few years ago CN Rail created something of a stir in mechanical circles with its development of a device called Positive Traction Control. Installed on 400 of CN's GP-40's, PTC produced adhesion improvements in the range of 15-20%. The railroad engaged Vapor Canada, Inc., to manufacture the device; subsequently, the Vapor Corp. of Chicago acquired worldwide licensing rights to PTC. What has happened since then? Has PTC lived up to the billing the Canadians gave it? The answer, at least as far as the Alaska Railroad is concerned, is "Yes." One of the first two U.S. railroads to acquire PTC units, the Alaska conducted its tests a few weeks ago; as a result ARR plans to equip its entire road fleet with PTC, in the expectation of annual fuel savings of up to 15% in addition to improved locomotive utilization. Results of the ARR tests are summarized in a letter to the editor (p. 48) from ARR General Manager F. H. Jones.

RAILWAY AGE

May 11, 1981

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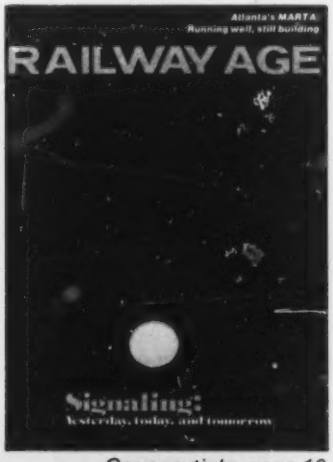

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The 100th anniversary of Union Switch & Signal is the occasion for this examination of the science of signaling and control—past, present, and the probable future as railroads enter the microprocessor era.

24 MARTA: Running well, still building
The first 11.8 miles of a projected 53-mile system is winning more riders than projected, and on-time performance was recently averaging around 99%. Two more segments totaling 4.5 miles will open this year and next.

32 Heavy rail transit for Honolulu?
Planners in the 50st state's capital city have concluded that buses alone can't do the job. Present thinking centers around an 8.4 mile rail line running between the airport and the university, and fed by buses.

39 Motive power: The coal-fired alternative
Backers of the ACE 3000 have produced studies that show their coal-burner stacking up favorably against straight electrics. Meanwhile, they're still trying to raise the $25 million needed to support the venture.

42 Coal: A time of challenge and opportunity
High-ranking executives representing a broad spectrum of coal interests paint a generally optimistic picture for both domestic and export coal, though many problems—including rate controversies—remain.

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COVER: Conrail's Morrisville, Pa., yard; Roy H. Blanchard photo.

Power: The coal-fired alternative

With electrification stubbornly showing returns on investment in the ho-hum range despite present and prospective massive oil/coal btu price differentials, a record turnout of members of the Southern and Southwestern Railway Association listened in Huntington, W. Va., to papers suggesting that converting coal to drawbar horsepower on the locomotive could raise ROI's to "let's go" levels without subjecting operating and maintenance officers to nightmares of unreliability and soaring shop costs.

The technology under discussion April 23 was the ACE 3000, a direct-drive, condensing steam locomotive designed by American Coal Enterprises, Inc. (*RA*, Oct. 13, 1980, p. 36). Along with the motive power units themselves, the ACE system envisions a logistic scheme for getting fuel and water aboard and ashes off the MU-capable, low-axle-load locomotives in a manner compatible with all operational requirements and within reasonable facility-cost bounds.

● **Ready-made scenarios.** In presenting more detailed financial projections for steamization, ACE Consultant John T. Harding (former Systems Manager for FRA's Office of High Speed Ground Transportation) was able to use FRA's published studies of U.S. railroad electrification costs and benefits and the underlying project memoranda produced by Transportation Systems Center analysts describing their detailed methodology, assumptions and scenarios. A particularly appropriate point of departure is the 26,000-route-mile network of electrification which formed the centerpiece of last October's Kansas City discussions between FRA and railroad officers (*RA*, Nov. 24, 1980, p. 26). Cost factor assumptions are summarized in Table I; the only change to the FRA report's diesel and electrification figures is an updating of fuel costs to December 1980 levels.

The assumed locomotive substitution rate in the FRA study is one 5,100-hp (3800 kW) electric for two 3,000-hp diesels, reflecting short-term acceleration capabilities with power from the wire; in the basic ACE comparison this ratio is also assumed since the coal-fired locomotive is designed to have low-speed characteristics equivalent to the 3000 hp diesel. ACE 3000 thermal efficiency at the drawbar is calculated at 18%, corresponding to the maximum of 32% for diesel-electric units of the best current design quoted in the Department of Energy-sponsored study of future propulsion systems for railroad locomotives, Phase B of which was reported by contractor Jet Propulsion Lab last December. For its study, ACE has assumed average coal-fired locomotive efficiency as half that of the diesel-electric in service, or 15%. Fuel cost is based on premium-price low-sulphur coal, with transportation and handling costs and the expenses of make-up water supply and treatment included; the ACE 3000's "service module" carries fuel for 500 miles ("15 hours at notch 8") or more, water for 1,000 miles. A principal factor in its efficiency and freedom from smoke is low-firing-rate combustion in a gasification mode which is reported to have achieved 12% drawbar thermal efficiency under normal operating conditions when applied to locomotives in Argentina and South Africa. Efficient auxiliaries supporting the compound, condensing cycle (including the microprocessor control of combustion, adhesion, expansion, and other power-generation aspects of operation which make it a one-man locomotive) provide bases for the remainder of the calculated improvement over previous steam standards while retaining direct (but fully balanced) reciprocating drive and modest (300 psi) working pressure compatible with fire-tube boiler design.

● **What a few billion might do.** Table II summarizes the figures from the FRA electrification and ACE coal-fired alternate motive power calculations for the middle-size (26,000 route-mile) national-network scenario in which the 14% of present route-miles carrying more than 50% of all ton-miles (generally, lines with density in excess of 30 million gross tons per year) are assumed to be shifted from diesel to alternate motive power.

The coal-fired estimates of the incremental investment require only locomotive-cost and coal/water service facility figures. The relatively long range and simplified coal- and ash-handling systems for the ACE 3000 keep the latter figure to about 3% of locomotive costs, which of course must remain relatively uncertain at this point when no prototype has been built. At least the quantities involved in this scenario support full economies of scale so far as production is concerned. At the one-for-two substitution ratio, the electric locomotives represent a very modest incremental investment in comparison to the $3.5 billion net for the coal-burners, but that in turn fades almost into insignificance when bounced against electrification costs which by now must be considered as well established as estimation can ever hope to do.

Annual net costs do favor the electric—maintaining half as many locomotives and ones without prime movers aboard saves almost $1 billion—but it is interesting to note that electrification transmission losses make overall energy costs using the same fuel lower for the self-contained motive power, even at the modest thermal efficiency assumed for the ACE locomotive.

● **Better than a money-market fund?** On the return-on-incremental-investment basis, though, the coal-fired alternative more than doubles that of electrification, whether or not it is assumed that diesel fuel cost will increase at more than the general rate of inflation. This is just a sample—the FRA study calculates rates of return for six scenarios: 10,000, 26,000 and 40,000-mile national networks and three site-specific maximum-density territories carrying unit coal trains, fast freight, and mixed traffic, respectively. Using exactly corresponding methodology and assumptions regarding traffic and cost escalation in each case, ROI's for the solid-fuel machines came out from 93% to 134% higher for the network cases and from 47% to 73% higher* for site-specific

Table I: Alternative motive power - cost factors

	Diesel	Electric		Coal-fired
Capital				
Roadway & facilities (per route-mile)		Single tk.	Double tk.	
Catenary	–	$175,000	$318,000	–
Substations, etc.	–	87,000	158,000	–
Comm. & signal mods.	–	142,000	210,000	–
Civil reconstruction (clearances)	–	54,000	79,000	–
Utility connections	–	15,000	15,000	–
Coal handling/water treatment facilities	–	–	–	$10,000
Total	Baseline – 0	$473,000	$775,000	$10,000
Locomotive units		$791,000 (3000 hp)	$1,540,000 (5100 hp)	$1,250,000 (Ace 3000)
Operating				
Energy	$.93/GAL	$.0423 KWH		$48/Ton (FOB locomotive)
Maintenance				
Locomotive	$1.33/Mile	$.65/Mile		$1.33/Mile
Catenary	–	$4400/Route-Mi./Yr.		–

*Assuming ACE 3000's replace diesels on a 1:1 ratio. Since its higher drawbar horsepower (up to 4000) at medium speeds might allow fewer of the reciprocating locomotives to do the job in some of the site-specific services, calculations were also made for 3:4 or 4:5 ratios as appropriate, in which case the coal-fired ROI's are much higher.

Table II: Alternative motive power Investment/Costs-credits/ROI/Net present value

26,000 Route-Mile Network
(15,600 Mi. Single/10,400 Mi. Double Track)
1980 Prices

	Electrification vs diesel	Coal-fired vs diesel
Traffic (million gtm/yr)	945,800	945,800
Locomotive fleet (units)	3400 (5100 hp)	6800 (3000 hp)
Investment ($ million)		
Catenary	6,040	–
Substations	3,000	–
Utility connections	390	–
Comm. & signal mods.	4,400	–
Civil reconstruction	1,660	–
Coal handling/water treatment facilities	–	260
Locomotives:		
New	5,240	8,500
Diesel transferred	(5,060)	(5,060)
Net investment	**15,670**	**3,700**
Annual cost-credits ($ million)		
Diesel loco replacement	(281)	(281)
Diesel fuel	(1,641)	(1,641)
Electric energy	1,110	–
Coal	–	970
Diesel loco maintenance	(1,360)	(1,360)
Elect./coal loco maintenance	409	1,360
Catenary maintenance	114	–
Net annual savings	**1,649**	**952**
Return on investment		
W/o fuel-cost escalation differential	12%	28%
With 3%/yr. diesel fuel esc. differential	15%	34%
Net present value*		
of investment ($ million)	**−155**	**+5,274**
Net present value ÷		
net investment	**−.01**	**1.43**

*10% discount rate, 30 year horizon

electrification where the high traffic density gives the capital-intensive catenary its best shot at profitability.

Pointing out that under budgetary constraints projects are ranked according to the ratio of "net present value" of calculated savings (after applying an appropriate discount rate to future benefits) to the investment required, Dr. Harding's analysis includes net-present-value-of-investment figures for the various scenarios. As shown in Table II, for the 26,000 mile network NPV is negative for the electrification, in contrast to a value well above the investment for the coal-fired alternative. In its most favorable scenarios, electrification shows some positive NPV (though never above about one quarter of the investment); for the coal burners, ratios are generally well above unity.

Study conclusion: "Coal compares very favorably relative to electrification. Furthermore, the NPV's for coal are very robust, remaining positive with considerable increases in investment cost. New forms of coal-fired steam locomotives should be considered seriously as an alternative motive power on the nation's railroads."

● **In the shop or on the road?** In the second presentation to the railroaders, American Coal Enterprises EVP William L. Withuhn came down to the problem of designing and building a locomotive with such characteristics—in particular, maintenance cost equivalent to today's best diesels.

"Locomotive development in this country is littered with examples of engines which were fine performers thermodynamically but which spent too much time on the servicing pad or in the shops," said Withuhn. "All types of engines—steam, steam turbine, gas turbine, straight electric, diesel-hydraulic, diesel-electric—are affected by the same principle: success in fleet service cannot come without low maintenance costs and low maintenance downtime...good maintenance must be designed into a locomotive; reliability, maintainability and high unit-availability cannot be added as 'afterthoughts' in the design process."

Citing the overriding characteristic of the ACE 3000 as simplicity, Withuhn traced the design-study process which led the ACE team away from its original tacit assumption that the new-era locomotive would be a turbine-electric. The turbine—gas or steam—has never worked well under the variable-load characteristics of railroad service; water tube boilers to generate the high pressures essential for turbine efficiency have never been successful in ordinary service on U.S. railroads. High-amperage electrical equipment, despite the solid-state revolution in rectification and control, remains a high-maintenance item, with one-third of total locomotive maintenance costs for a typical large railroad going into alternators, traction motors, resistor grids and the like.

Most of the presentation was devoted to specific examples among the myriad of design decisions based on reliability, availability and maintainability considerations and fitted into the go anywhere-do anything concept taken from forty years of diesel-electric success:

—All roller bearings on axles, drive rods and valve gear designed to the modern and proven fully-sealed "No Field Lubrication" philosophy.

—Self-lubricating synthetic materials on parts such as journal-box liners and crossheads, eliminating open lubrication.

—Control of water chemistry within the closed cycle, eliminating water-side scale for operation for a full year between washouts.

—A clean combustion process, reducing flyash carryover to the point of eliminating cinder-cutting of tubes and superheaters.

—All servicing—sand, water, lubricants, fuel—done from ground level.

● **But what about the day AFTER tomorrow?** Implicit in any consideration of development of a substantially different form of motive power is the matter of its longevity, recognizing that only prototypes running successfully on the main line will give full credibility to the newcomer, and at best that's not a matter of a few bucks or a few weeks. The third phase of the DOE/JPL study mentioned above has looked into the next two decades, considering possibilities (ranging from Stirling-cycle engines to Rankine-bottoming diesel addenda) of all degrees of elegance and iffyness. The final report, which will enter the pre-release public review process next month, is anticipated with considerable confidence by the bituminous partisans—if that is any indication of the situation.

Meanwhile, what about American Coal Enterprises' progress in obtaining the private-sector funding required to put a prototype or two on the rails? A spokesman says: "We have many irons in the fire, and a firm commitment from a securities underwriter which greatly reduces the up-front funding [$25 million or so] necessary to put the show on the road; nothing more can be said at this point." ■

—John Armstrong

Market

CARLOADINGS

Loadings of revenue freight in the week ended Apr. 25 totaled 384,783 cars, according to the Association of American Railroads. This was a decrease of 69,890 cars, or 15.4%, compared with the corresponding week last year. Ton-miles generated by carloadings in the week ended Apr. 25 are estimated at 16.2 billion, a decrease of 8.6% below the corresponding week of 1980.

REVENUE FREIGHT CARLOADINGS

Commodity	Apr. 25 week	Apr. 18 week	Apr. 11 week
Grain	23,359	21,824	24,399
Farm products	3,581	3,714	3,720
Metallic ores	32,815	30,377	27,813
Coal	60,973	60,552	58,920
Crushed stone, gravel & sand	15,082	13,972	14,434
Nonmetallic minerals	14,972	13,855	13,870
Grain mill products	13,589	13,709	14,470
Food and kindred products	16,019	14,968	15,680
Primary forest products	20,005	18,924	19,407
Lumber & wood products (except furniture)	9,405	9,205	9,040
Pulp, paper & allied products	20,205	19,394	19,650
Chemicals & allied products	28,537	27,478	27,768
Petroleum products	4,802	4,496	5,250
Stone, clay & glass products	14,885	14,071	15,117
Coke	6,208	5,655	6,308
Metals & products	18,176	16,372	17,244
Motor vehicles & equipment	18,986	17,084	18,872
Waste & scrap materials	13,128	12,555	13,959
Forwarder & shipping assn. traffic	10,080	10,191	10,879
All other carloads	39,786	39,269	42,294
LCL traffic	190	216	233
Total cars loaded	**384,783**	**367,881**	**379,327**
Cumulative total, 17 weeks		**7,149,889** 1981	**7,509,052** 1980
Estimated revenue ton-miles (billions), 17 weeks		**16.2**	**17.7**

PIGGYBACK LOADINGS

U.S. piggyback loadings for the week ended Apr. 18 totaled 31,016 cars (5.0% below the corresponding 1980 week) and 57,294 trailers or containers (down 3.5% from 1980). Cumulative volume for the first 16 weeks of 1981 is 510,980 cars (down 4.5% from 1980) and 927,336 trailers or containers (down 4.5% from 1980).

- *Indian Railways.*—Awarded a $2-million contract to Litton Unit Handling Systems of Cincinnati for a conveyor system for railroad wheel finishing. The system will convey 1,200-pound wheels at the rate of one wheel a minute; it is to be functioning by July 1982.

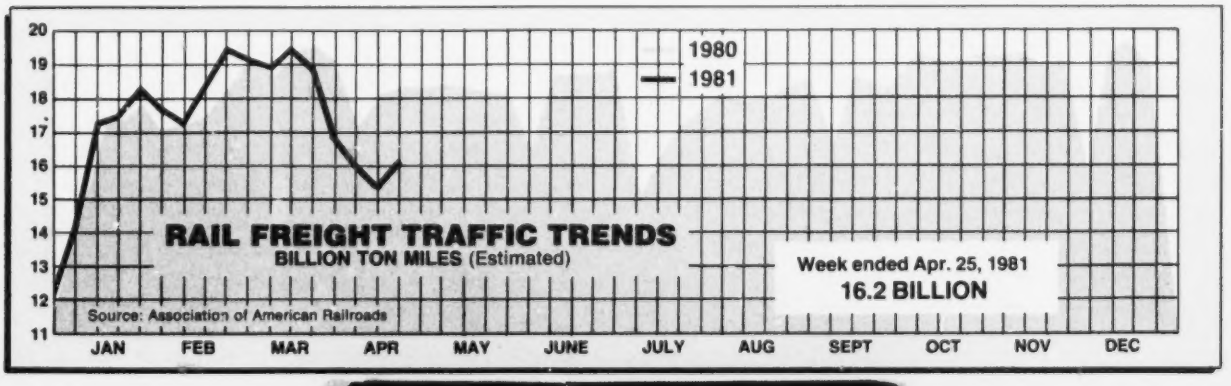
- *Kenya Railways Corp.*—Will use proceeds of a $58-million World Bank loan to help finance a $133.8-million improvement program. The program includes replacement of rail; purchases of track and workshop equipment; acquisition of hopper cars and spare parts for locomotives and cars; and yard improvements. Equipment and material financed by the loan will be obtained through international competitive bidding in accordance with World Bank guidelines except for orders under $100,000.

- *Port Authority Transit (Pittsburgh).*—Awarded three contracts with a total value in excess of $6.3 million to Bethlehem Steel for the supply of special track items, 10 portable track crossovers, and 1,270 tons of running rail for installation at the South Hill Village car yards and shop. A $7.46-million contract was awarded to the Massaro Corp. for construction of a building to accommodate a new maintenance center at South Hills Village. With the award of these contracts, approximately $25 million has now been commited to work on the South Hills Light Rail Transit (LRT) system.

- *Massachusetts Bay Transportation Authority.*—General Railway Signal is the apparent low bidder, at $14.2 million, for signaling the Harvard to Alewife extension of MBTA's Red Line. The GRS proposal includes high-frequency track circuits, preprogrammed train dispatching, supervisory control consoles with train and equipment status displays, a high-speed solid-state electronic data transmission system, an electronic car identity system, and automatic routing of trains.

- *Southern*—Awarded a $4.2-million contract to GTE for the supply and installation of microwave radio equipment and antenna systems at 40 sites between Albany, Ga., and Harriman, Tenn. This is the third phase of an ongoing program to upgrade Southern's microwave network.

- *Zimbabwe.*—Awarded a $40-million contract to General Motors for the supply of 25 2,250-hp diesel-electric locomotives and related services. The six-axle units are designated GT22LC. The purchase is being financed by a loan from the Kuwaiti Fund for Arab Development. The new locomotives, to be delivered this year, will replace units that have been leased from South African Railways.



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